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AIR QUALITY MONITORING STUDIES CARRIED OUT IN THE CITY OF NORTH BAY FROM 1971 TO 1986

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Ministry of the Environment

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Minister

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SUMMARY

The Ontario Ministry of the Environment has monitored ambient sulphur dioxide (SO_2) and particulate levels in North Bay since 1971 as part of a Provincial monitoring program, and because of concerns that the tall stack commissioned by Inco Ltd. in September of 1972 would have an adverse affect on air quality.

Particulate matter was monitored using soiling index (COH) monitors, high-volume samplers and dustfall jars. Sulphur dioxide levels were monitored using continuous analysers, and sulphation rate was monitored using sulphation candles/plates.

Data collected from 1971 to 1986 showed only one elevated hourly SO_2 value (in 1975) that could be attributed to the Sudbury Inco operations.

Particulate monitors indicated low levels of coarse and fine particulate in the City, with only a few exceedences of the 24 hour criterion for suspended particulate being recorded.

The Ontario Ministry of the Environment will continue to monitor ambient air quality in the City of North Bay as part of the Provincial air quality network. In addition, new monitors, to be installed as part of a new Province-wide Air Quality Index network, will be commissioned within the next year.

RÉSUMÉ

Depuis 1971, le ministère de l'Environnement de l'Ontario mesure la concentration de l'anhydride sulfureux (SO_2) et de particules dans l'air dans la région de North Bay, dans le cadre d'un programme provincial de surveillance de la qualité de l'air. Ces travaux font aussi suite aux préoccupations qui ont été formulées lorsque la société Inco Ltd. a décidé, en septembre 1972, de construire une grande cheminée pour ses usines de Sudbury.

Les concentrations de particules sont mesurées au moyen de capteurs donnant l'indice de noircissement (COH), d'échantillonneurs à gros débit et de collecteurs de poussières. La teneur en anhydride sulfureux est mesurée par des analyseurs en continu, alors que le taux de sulfatation est mesuré au moyen de plaques ou bougies filtrantes de sulfatation.

Les données recueillies entre 1971 et 1986 démontrent qu'il n'y a eu qu'une seule augmentation de la concentration horaire de SO_2 (en 1975) que l'on pourrait attribuer à l'usine Inco de Sudbury.

Les analyseurs de particules n'ont détecté qu'une faible concentration de particules fines et grosses en ville et que quelques rares cas où les concentrations de particules en suspension dépassaient les limites fixées pour une période de 24 heures.

Dans le cadre du programme provincial de surveillance de la qualité de l'air, le ministère de l'Environnement continuera de mesurer la teneur de l'air en polluants dans la région de la ville de North Bay. Par ailleurs, le Ministère a l'intention de se procurer, au cours de la prochaine année, d'autres appareils de surveillance qui feront partie du nouveau réseau provincial de surveillance de la qualité de l'air.

INTRODUCTION

The Ontario Ministry of the Environment collected ambient air quality data in the City of North Bay as part of a Provincial program to monitor outdoor air quality in urban areas. Sulphur dioxide, sulphation rate and particulate levels were monitored at the old Teachers' College (now part of Canadore College) from 1971 to 1979 and at the Ontario Provincial Police station from 1979 to 1986.

This report summarizes data collected in North Bay from June of 1971 to December of 1986 for the routine air quality monitoring/surveillance program established by the Ministry in 1971.

MONITORING PROGRAM

Sulphur Dioxide

Sulphur dioxide (SO_2) is a major atmospheric pollutant with many adverse affects ranging from localized effects on health (when combined with particulate matter) and vegetation to long-range effects such as production of acid rain. The principal sources of SO_2 emissions in North Bay are residential and commercial space heating and some small industrial sources. On occasion, under certain meteorological conditions, emissions from the smelting operations in Sudbury may also effect the sulphur dioxide levels in ambient air in the City of North Bay.

Sulphur dioxide levels in North Bay have been monitored in part because of concerns of the potential impact of the construction of the tall stack at the Inco Ltd. smelter in Copper Cliff.

Sulphur dioxide and particulates have been monitored as part of an overall Provincial monitoring program to determine trends and to ensure compliance with Provincial standards, criteria and objectives.

Ambient sulphur dioxide levels were monitored at the Teachers' College, (Station 75020) on Fifth Avenue and Fraser Street in North Bay, from June of 1971 to June of 1979. Sulphur dioxide was monitored on a continuous 24 hour basis, initially using wet chemical techniques outlined in the Appendix. The wet chemical monitors were later replaced with electronic pulsed fluorescent analyzers, the operation of which is also described in the Appendix.

In July of 1979, the continuous SO_2 monitor, along with the other monitors, was relocated to the Ontario Provincial Police station (75010) because of reoccurring vandalism at the Teachers' College site.

The ambient air quality criteria for sulphur dioxide (SO_2), as outlined in Ontario Regulation 296 are as follows: 0.25 parts of SO_2 per 1,000,000 parts of air by volume (ppm)

for a one hour average (based on protection of vegetation); a 24 hour average of 0.10 ppm, based on health effects in conjunction with soiling index and visibility, and an annual average of 0.02 ppm, again based on protection of sensitive vegetation.

Sulphation Rate

Sulphur dioxide levels can also be measured using a passive sampler (sulphation candle/plate) which provides a semi-quantitative estimate of the presence of sulphur containing compounds.

Samples are collected over a one month period, with the results expressed as milligrams of sulphur trioxide per 100 square centimeters of exposed lead peroxide (PbO_2) per day (mg SO_3/100 cm^2/day). The Provincial Criterion for sulphation rate is 0.7 mg SO_3/100 cm^2/day, as outlined in Regulation 296. A description of the sulphation plate monitor is outlined in the Appendix.

Sulphation rate was monitored at the Teachers' College (75020) location in North Bay from 1971 to 1979 using lead peroxide candles and/or plates.

Particulate Matter

Particulate matter results from anthropogenic and natural sources. Natural sources of particulate include volcanic activity, forest fires and soil erosion. Anthropogenic sources include construction, manufacturing, residential heating using both fossil and contemporary fuels, and transportation.

Particulates may have adverse effects on human and animal health, depending on the size and makeup of the particulate. Particulates may also affect visibility and vegetation and cause soiling from both wet and dry deposition.

In the City of North Bay, particulates have been measured as soiling index, total suspended particulate and dustfall.

Soiling Index

Soiling index is measured using an electronic monitor and relates to the amount of particulate in ambient air. Soiling Index was monitored at the Teachers' College (75020) from June of 1971 to June of 1979 and at the OPP station (75010) from July of 1979 to December, 1980. A description of the method used for the measurement of soiling index is presented in the Appendix.

The desirable ambient air quality criterion for soiling index reported in Coefficient of Haze units (COH) is 1.0/1,000 ft. of air over 24 hours and 0.5/1,000 ft. of air averaged over one year. Both criteria are based on health effects in conjunction with elevated SO_2 levels. Since the COH monitors are electronic devices which measure light transmittance, they can provide real-time data and are used in numerous communities throughout the Province to produce the air pollution index (API) values. The API was not reported in North Bay.

Total Suspended Particulates

Total Suspended Particulate matter (TSP) consists of suspended material which remains entrained in the air for a substantial period of time (i.e. does not settle out readily because of its mass and is usually less than 100 microns or equivalent aerodynamic diameter). It is measured using a high-volume sampler (hi-vol), the operation of which is discussed in the Appendix. A portion of the TSP is within the respirable fraction and can therefore be responsible for adverse health effects. The ambient air quality criteria are 120 micrograms per cubic meter of air (ug/m^3) for 24 hours and 60 ug/m^3 geometric mean for a one year period. At the present time, there are no criteria or objectives for particulate matter in the respirable fraction.

Filters collected using the hi-vol technique can be analyzed for various elements and compounds to determine trace concentrations.

High-volume samples were collected at the Teachers' College (75020) from 1971 to 1979 and at the OPP station (75010) from 1979 to 1984. Hi-vol samples were analyzed for iron, nickel, chromium, cadmium, arsenic, manganese, vanadium, sulphates and nitrates. Provincial Objectives for these trace compounds are presented in Table 19 in the section on monitoring results.

Dustfall

Dustfall is a measure of large particulate matter that settles out of the air by gravity. Total Dustfall provides an estimate of coarse particulate levels due to emissons from nearby sources. Dustfall sampling techniques are described in the Appendix. The ambient air quality criteria for dustfall are 7.0 grams per square meter per 30 days (7.0 g/m^2/30 days) and 4.5 g/m^2/30 days for a one year period.

Dustfall data were collected at the Teachers' College (75020) from September, 1972 to May, 1979 and at the OPP station (75010) from July, 1979 to April, 1984.

MONITORING RESULTS

A list of monitoring locations and parameters is presented in Table 1, and locations of monitors are shown in Figure 1.

Sulphur Dioxide

The data acquisition record and annual mean sulphur dioxide concentrations are presented in Table 2. Annual mean SO_2 levels from 1971 to 1986 are also presented in graphical form in Figure 2. Annual mean SO_2 levels were well below the Provincial ambient air quality criterion of 0.02 ppm, outlined in Regulation 296. In 1971, the annual mean was at the Provincial criterion, but this average consists of only 361 readings and does not constitute a valid mean.

A summary of 24 hour maximum SO_2 concentrations from 1971 to 1986 is presented in Table 3. Also included in this table are the maximum one hour concentrations in ppm. This table shows that the 24 hour Provincial criterion of 0.10, outlined in Ontario Regulation 296, was never exceeded during this entire sampling period.

A distribution of sulphur dioxide hourly readings from 1971 to 1986 is presented in Table 4. The Provincial criterion of 0.25 ppm for one hour, outlined in Regulation 296, was

exceeded in North Bay once in 1971 and once in 1975 when the monitor was located at the Teachers' College. The one-hour criterion has not been exceeded in North Bay since 1975. The elevated one-hour reading (greater than 0.25 ppm) which occurred in 1975 can be attributed to the Inco Sudbury operations. The elevated hourly value recorded in November of 1971 was most probably caused by similar meteorological conditions, but this cannot be verified because upper level meteorological data was not available in Sudbury at that time. These two hours represent 0.001 percent of a total number of hourly readings.

Sulphation Rate

A summary of sulphation rate data collected at Teachers' College (75020) from August, 1971 to June, 1979, is presented in Table 5 and graphically in Figure 3. Monthly sulphation rate ranged from a low of 0.03 to 0.52 mg $SO_3/100$ cm^2/day. None of the samples collected over the nine-year period exceeded the monthly Provincial criterion of 0.70 $mg/100cm^2/day$ (30-day period). The results confirm that the ambient concentrations of sulphur dioxide in North Bay are generally very low and within acceptable levels.

Particulate Matter

Soiling Index

A summary of soiling index data collected in North Bay from July of 1971 to March of 1980 is presented in Table 6 and in Figure 4.

The soiling index did not exceed the Provincial criterion of 1.0 COH units per 1,000 feet of air for a 24 period or 0.5 COH units/100 ft. of air over a one year period at Teachers' College (75020) from 1971 to 1979 or at the OPP station (75010) from 1979 to 1980.

Total Suspended Particulate

A summary of total suspended particulate data collected at the Teachers' College (75020) and the OPP station (75010) from 1971 to 1984 is presented in Table 7 and in Figure 5. Summaries of analyses for trace metals and compounds are presented in Tables 8 to 15 and in Figures 6 to 13.

Results show that suspended particulate levels in the City of North Bay were low, with the 24 hour criterion of 120 ug/m^3 being exceeded on only six occasions from 1971 to 1986. The yearly criterion of 60 ug/m^3 geometric mean was not exceeded during the entire sampling period.

High-volume (hi-vol) filters were analyzed for various compounds and trace elements. The following table lists the hi-vol analysis for the City of North Bay from 1971 to 1986.

Summary of Hi-Vol Analysis and Provincial Criteria
for the City of North Bay from 1971 to 1986

Compound	Limiting Effect	Provincial Criteria (ug/m^3)	Number Above Provincial Criteria
Arsenic	Health	5	0
Cadmium	Health	2	0
Chromium	Health	10	0
Iron	Soiling	4 metallic	3
Lead	Health	5	0
Manganese	TSP standard	50	0
Nickel	Vegetation	2	1
Vanadium	Health	2	0
Nitrates	----------No Provincial Criteria----------		
Sulphates	----------No Provincial Criteria----------		

24 hr. Ambient Air Quality Criteria

Hi-vol filters were analyzed for trace elements (As, Cd, Cr, Fe, Pb, Mn, Ni, Vn) and two compounds (nitrates and sulphates). Iron exceeded the Provincial criterion of 4 ug/m^3 (metallic) for 24 hours on three occasions. The Provincial criterion of 4 ug/m^3 for a 24 hour period is for metallic iron. The Ministry of the Environment laboratories analyse for total iron and report total iron, and, as a result, the number of occasions on which the metallic iron criterion was exceeded may be somewhat less. Nickel exceeded the Provincial criterion 2 ug/m^3 on one occasion. All other elements were well below the Provincial criteria.

Care must be taken when interpreting results for metal analysis in T.S.P. Low numbers of filters were analysed for metals in specific years, and the annual means are not valid; therefore, care must be taken not to infer poorer air quality in these years since all values were well below Provincial objectives.

The geometric mean for nitrates in suspended particulate varied from 0.7 to 2.6 ug/m^3, with the maximum mean value being observed in 1978 at the Teachers' College location. Nitrate levels remained relatively constant throughout the monitoring period.

Sulphate levels in suspended particulate collected on hi-vols from 1971 to 1986 remained relatively constant, with no obvious trends over the 16 year period. Geometric mean sulphate levels ranged from 3.8 to 9.1 ug/m^3. Some artifact formation of sulphates on glass fibre filters has been reported in recent years; therefore, sulphate levels may actually be somewhat lower than reported.

It must be pointed out that the number of samples analyzed for sulphates and nitrates were not consistent from year to year, with relatively small samples being analyzed during the earlier years. Therefore, a comparison of yearly geometric means may be misleading.

Dustfall

Total dustfall levels, in North Bay at the Teachers' College (75020), were variable with several elevated samples collected during the no snow cover period (April to September) in 1973 and 1976. The annual mean dustfall was above the Provincial criterion of 4.5 $g/m^2/30$ days in 1973, 1974 and 1976. Total dustfall data are presented in Tables 16 and 17 and in Figure 14.

Total dustfall levels were lower at the OPP station (75010), with only one monthly sample exceeding the Provincial criterion of 7.0 $g/m^2/30$ days from July of 1979 to April of 1984, when the monitoring was discontinued.

CONCLUSION

The ambient air quality monitoring program carried out in the City of North Bay from 1971 to 1986 indicates acceptable air quality with respect to sulphur dioxide and particulate matter.

Although sulphur dioxide levels were slightly higher in the downtown area during earlier years (1971 to 1979), levels are well within Provincial Criteria. Effects of the Inco Ltd. tall stack in Copper Cliff has had little or no adverse effect on the air quality in North Bay since it was commissioned in September, 1972, with the exception of one elevated hourly value in 1975.

Particulate matter monitored using soiling index, high-volume and dustfall monitors indicated low levels of particulates in the City. Any exceedence of the suspended particulate and dustfall criteria can be attributed to traffic and construction activities in a community of this size. Although lead levels in suspended particulate were not considered elevated, it is interesting to note steady decreasing trend from 1971 to 1986. This would, in part, be a result of the relocation of the monitor from the downtown area in 1979 and a decrease in the use of lead in motor fuels.

FUTURE MONITORING

The Ontario Ministry of the Environment will continue to monitor ambient air quality in the City of North Bay as part of its Provincial air quality network. Sulphur dioxide and particulate will be monitored. In addition, North Bay will become part of a Province-wide air quality index network that is to be commissioned by the Ministry in the near future and will provide real-time air quality data for a greater number of air contaminants.

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TABLE 1

AIR MONITORING STATION LOCATION AND PARAMETERS MONITORED IN NORTH BAY FROM 1971 TO 1986

STATION	LOCATION	POLLUTANT MONITORED					INSTALLED	DISCONTINUED
		SO_2	TSP	D	SO_x	COH		
75010	OPP Station North Bay	X	X	X			June 1979	
75020	Teachers College First Ave/Fraser St.	X	X	X	X	X	June 1971	June 1979

Note: D - Dustfall
TSP - Total Suspended Particulate
SO_x - Sulphation Plate
COH - Coefficient of Haze

TABLE 2

DATA ACQUISITION RECORD AND ANNUAL MEAN SO_2 LEVELS
FOR MONITORING STATIONS IN THE NORTH BAY AREA FROM 1971 TO 1986

STATION	YEAR	PERCENT VALID DATA	NO. OF READINGS	AVERAGE CONC. (PPM)
75020 (Teachers College)	1971	50.1	361	0.02
	1972	69.5	5089	0.009
	1973	78.2	6854	0.009
	1974	94.1	8246	0.006
	1975	95.0	8353	0.008
	1976	96.5	8476	0.01
	1977	91.3	8002	0.006
	1978	86.5	7577	0.004
	1979a*	95.1	3448	0.007
75010 (OPP Station)	1979b*	85.7	4400	0.003
	1980	94.7	7613	0.004
	1981	98.3	8607	0.002
	1982	97.2	8513	0.003
	1983	92.7	8118	0.002
	1984	72.7	5320	0.002
	1985	77.0	6744	0.002
	1986	94.0	8231	0.002

Provincial Criterion for SO_2: 0.02 ppm for a 1 year average

* Station relocated to site 75010 in July, 1979.

TABLE 3

MAXIMUM MEAN SO_2 CONCENTRATION AND FREQUENCY OF EXCEEDANCE OF PROVINCIAL CRITERION IN NORTH BAY FROM 1971 TO 1986

STATION	YEAR	1 HR. MAX. CONC. (ppm)	24 HR. MAX. CONC. (ppm)	NO. OF TIMES ABOVE PROVINCIAL CRITERIA (24 hour average)
75020 (Teachers College)	1971	.28	.04	0
	1972	.17	.05	0
	1973	.20	.04	0
	1974	.16	.05	0
	1975	.30	.06	0
	1976	.20	.04	0
	1977	.13	.04	0
	1978	.22	.04	0
	1979	.09	.04	0
75010 (OPP Station)	1979	.15	.02	0
	1980	.11	.03	0
	1981	.12	.02	0
	1982	.10	.04	0
	1983	.06	.02	0
	1984	.11	.03	0
	1985	.07	.02	0
	1986	.08	.02	0

Provincial Criterion for SO_2: 24 Hr. Average = 0.10 ppm
1 Hr. Average = 0.25 ppm

TABLE 4

DISTRIBUTION OF THE SULPHUR DIOXIDE HOURLY READINGS RECORDED IN THE NORTH BAY AREA FROM 1971 TO 1986

STATION	YEAR	NO. OF HOURLY READINGS IN STATED CONCENTRATION RANGE					
		0-0.10	0.11-0.25	0.26-0.49	0.50-0.99	1.00	TOTAL
75020 (Teachers College)	1971	358	2	1	0	0	361
	1972	5081	8	0	0	0	5089
	1973	6848	6	0	0	0	6854
	1974	8241	5	0	0	0	8246
	1975	8347	10	1	0	0	8358
	1976	8467	9	0	0	0	8476
	1977	8000	2	0	0	0	8002
	1978	7573	4	0	0	0	7577
	1979	3448	0	0	0	0	3448
75010 (OPP Station)	1979	4395	5	0	0	0	4400
	1980	7612	1	0	0	0	7613
	1981	8606	1	0	0	0	8607
	1982	8513	0	0	0	0	8513
	1983	8118	0	0	0	0	8118
	1984	5319	1	0	0	0	5320
	1985	6744	0	0	0	0	6744
	1986	8231	0	0	0	0	8231
TOTAL			54	2	0	0	105726

PROVINCIAL CRITERION FOR SO_2: 1 Hr. Average = 0.25 ppm

TABLE 5

LEVEL OF SULPHATION ON LEAD PEROXIDE PLATES AT TEACHERS COLLEGE
FIRST AVENUE/FRASER STREET, STATION 75020, NORTH BAY
FROM 1971 TO 1979
(mg SO_3/100 cm^2/day)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	MEAN
1971	-	-	-	-	-	-	-	0.17	0.05	0.21	-	0.33	0.19
1972	0.52	0.32	0.16	-	0.08	0.10	0.08	0.07	0.09	0.20	0.18	0.20	0.18
1973	0.21	0.18	0.10	-	0.10	0.11	0.06	0.06	0.19	-	0.21	0.40	0.16
1974	0.24	0.32	0.18	0.56	0.20	0.04	0.10	0.03	0.13	0.15	0.16	0.18	0.19
1975	0.30	0.27	0.14	0.10	0.15	0.28	0.11	0.09	0.13	0.15	0.04	-	0.16
1976	-	0.36	0.23	0.56	0.08	0.09	0.07	0.07	0.14	0.23	0.31	0.22	0.21
1977	0.22	0.40	0.20	0.12	0.20	-	0.01	0.28	0.06	0.15	-	0.41	0.21
1978	0.47	0.47	0.28	0.21	-	0.14	0.07	-	-	0.11	-	0.26	0.25
1979	0.25	0.39	0.35	-	-	-----Discontinued June, 1979----------							0.33

- Indicates missing or invalid data
Provincial Criterion: 0.70 mg SO_3/100 cm^2/day (30 day period)

TABLE 6

TOTAL LEVEL OF PARTICULATES (Soiling Index 2 Hour Samples)
COLLECTED IN NORTH BAY FROM 1971 TO 1980
(0.1 COH units/1000 ft.)

YEAR	MEAN	SAMPLE SIZE	MINIMUM	PERCENTILES							MAXIMUM 24 HR	NO. OF TIMES OVER 10 24 HR
				10	30	50	70	90	95	99		
TEACHERS COLLEGE, FIRST AVENUE/FRASER STREET, NORTH BAY												
1971	1.8	1349	0	0.0	0.0	1.3	1.9	3.5	4.6	7.4	5	0
1972	1.9	2739	0	0.0	0.2	1.3	1.9	3.6	4.7	8.4	8	0
1973	1.9	3900	0	0.0	0.0	1.3	2.0	4.1	5.0	8.4	8	0
1974	1.7	2109	0	0.0	0.0	1.1	1.8	3.4	4.6	8.1	7	0
1975	1.6	3383	0	0.0	0.0	0.7	1.8	3.9	4.9	8.5	6	0
1976	1.8	3692	0	0.0	0.0	1.0	1.9	4.3	5.4	8.5	5	0
1977	1.9	3898	0	0.0	0.0	1.2	1.9	3.8	5.2	9.0	7	0
1978	1.7	3997	0	0.0	0.0	1.1	1.8	3.4	4.8	9.0	7	0
1979	1.6	1741	0	0.0	0.0	0.5	1.7	3.3	4.9	10.3	6	0
1979	1.2	1919	0	0.0	0.0	0.1	1.4	2.5	3.6	6.1	4	0
1980	1.4	900	0	0.0	0.0	0.6	1.5	2.8	4.1	6.6	4	0

Provincial Criterion: 1.0 COH Units/1000 ft. of air for 24 hrs.

TABLE 7

SUMMARY OF TOTAL SUSPENDED PARTICULATE IN THE NORTH BAY AREA FROM 1971 TO 1986

STATION	YEAR	NUMBER OF SAMPLES	MAXIMUM 24hr VALUE (ug/m^3)	GEOMETRIC MEAN (ug/m^3)	NUMBER OF SAMPLES ABOVE PROVINCIAL CRITERION
75020 (Teachers College)	1971	20	111	41	0
	1972	58	117	42	0
	1973	35	103	39	0
	1974	50	101	43	0
	1975	41	108	34	0
	1976	49	149	46	2
	1977	11	198	53	1
	1978	6	47	27	0
	1979	12	104	48	0
75010 (OPP Station)	1979	45	104	34	0
	1980	41	153	46	3
	1981	40	95	37	0
	1982	45	92	34	0
	1983	54	100	33	0
	1984	47	112	37	0
	1985	50	61	25	0
	1986	43	94	28	0
					6

Provincial Criterion: 120 ug/m^3 (24 hour period)
60 ug/m^3 (1 year period)

TABLE 8

TOTAL LEVEL OF CHROMIUM IN SUSPENDED PARTICULATE IN THE NORTH BAY AREA FROM 1971 TO 1986

STATION	YEAR	NUMBER OF SAMPLES	MAXIMUM 24hr. VALUE (ug/m^3)	GEOMETRIC MEAN (ug/m^3)
75020 (Teachers College)	1971	8	0.014	0.002
	1972	41	0.007	0.001
	1973	28	0.020	0.002
	1974	--	--	--
	1975	1	0.00	0.00
	1976	7	0.00	0.00
75010 (OPP Station)	1981	11	0.005	0.001
	1982	45	0.022	0.003
	1983	50	0.019	0.001
	1984	47	0.015	0.001
	1985	40	0.030	0.010
	1986	33	0.023	0.007

-- Indicates missing or invalid data
Provincial Guideline: 10 ug/m^3 (24 hr.)

TABLE 9

TOTAL LEVEL OF IRON IN SUSPENDED PARTICULATE IN THE NORTH BAY AREA FROM 1971 TO 1986

STATION	YEAR	NUMBER OF SAMPLES	MAXIMUM 24hr VALUE (ug/m^3)	GEOMETRIC MEAN (ug/m^3)
75020 (Teachers College)	1971	8	2.4	1.5
	1972	41	6.7	1.3
	1973	28	2.9	0.7
	1974	48	2.5	0.5
	1975	40	3.5	0.6
	1976	42	3.9	1.0
	1977	8	8.4	0.7
	1978	6	1.0	0.7
	1979	12	4.4	1.0
75010 (OPP Station)	1979	45	1.2	0.2
	1980	42	3.1	0.6
	1981	41	3.0	0.4
	1982	45	2.9	0.5
	1983	54	2.0	0.2
	1984	47	2.0	0.3
	1985	40	0.8	0.3
	1986	30	3.5	0.4

-- Indicates missing or invalid data
Provincial Criterion: 4 ug/m^3(24 hrs.)

TABLE 10

TOTAL LEVEL OF LEAD IN SUSPENDED PARTICULATE IN THE NORTH BAY AREA FROM 1971 TO 1986

STATION	YEAR	NUMBER OF SAMPLES	MAXIMUM 24hr VALUE (ug/m^3)	GEOMETRIC MEAN (ug/m^3)	NUMBER OF SAMPLES ABOVE PROVINCIAL CRITERION
75020 (Teachers College)	1971	8	1.3	0.50	
	1972	41	1.4	0.50	
	1973	29	1.5	0.50	
	1974	5	0.9	0.60	
	1975	39	1.5	0.30	
	1976	42	1.6	0.40	
	1977	8	1.3	0.40	
	1978	6	1.0	0.40	
	1979	12	1.5	0.40	
75010 (OPP Station)	1979	45	1.0	0.20	
	1980	42	1.1	0.20	
	1981	41	0.8	0.20	
	1982	45	0.8	0.20	
	1983	54	0.9	0.20	
	1984	47	1.0	0.1	
	1985	40	0.5	0.1	
	1986	30	0.4	0.1	

-- Indicates missing or invalid data
Provincial Criterion: 5.0 ug/m^3 (24 hr. period)

TABLE 11

TOTAL LEVEL OF MANGANESE IN SUSPENDED PARTICULATE IN THE NORTH BAY AREA FROM 1971 TO 1986

STATION	YEAR	NUMBER OF SAMPLES	MAXIMUM 24hr VALUE (ug/m^3)	GEOMETRIC MEAN (ug/m^3)
75020 (Teachers College)	1971	8	0.040	0.010
	1972	41	0.060	0.010
	1973	28	0.090	0.030
	1974	2	0.010	0.010
	1975	--	--	--
	1976	7	0.050	0.020
75010 (OPP Station)	1981			
	1982	44	0.069	0.015
	1983	54	0.065	0.007
	1984	47	0.042	0.008
	1985	40	0.047	0.015
	1986	32	0.066	0.010

-- Indicates missing or invalid data
Provincial Criterion: 50 ug/m^3 (24 hr.)

TABLE 12

TOTAL LEVEL OF NICKEL IN SUSPENDED PARTICULATE IN THE NORTH BAY AREA FORM 1971 TO 1986

STATION	YEAR	NUMBER OF SAMPLES	MAXIMUM 24hr VALUE (ug/m^3)	GEOMETRIC MEAN (ug/m^3)
75020 (Teachers College)	1971	8	0.710	0.014
	1972	42	0.130	0.014
	1973	29	0.030	0.003
	1974	48	0.260	0.014
	1975	39	2.000	0.007
	1976	42	0.038	0.003
	1977	8	0.031	0.008
	1978	6	0.020	0.004
	1979	12	0.023	0.004
75010 (OPP Station)	1979	45	0.019	0.003
	1980	42	0.430	0.003
	1981	41	0.010	0.001
	1982	45	0.028	0.002
	1983	54	0.006	0.000
	1984	46	0.044	0.001
	1985	40	0.030	0.005
	1986	33	0.010	0.004

-- Indicates missing or invalid data
Provincial Criterion: 2 ug/m^3 (24 hrs.)

TABLE 13

TOTAL LEVEL OF VANADIUM IN SUSPENDED PARTICULATE IN THE NORTH BAY AREA FROM 1971 TO 1986

STATION	YEAR	NUMBER OF SAMPLES	MAXIMUM 24hr VALUE (ug/m^3)	GEOMETRIC MEAN (ug/m^3)
75020 (Teachers College)	1971	8	0.01	0.00
	1972	41	0.04	0.01
	1973	29	0.05	0.01
	1974	2	0.00	0.00
	1975	--	--	--
	1976	7	0.05	0.02
75010 (OPP Station)	1981	11	0.009	0.001
	1982	44	0.010	0.002
	1983	54	0.027	0.000
	1984	47	0.085	0.001
	1985	40	0.012	0.009
	1986	33	0.010	0.006

-- Indicates missing or invalid data
Provincial Criterion: 2 ug/m^3 (24 hr.)

TABLE 14

TOTAL LEVEL OF ZINC IN SUSPENDED PARTICULATE IN THE NORTH BAY AREA FROM 1971 TO 1986

STATION	YEAR	NUMBER OF SAMPLES	MAXIMUM 24hr VALUE (ug/m^3)	GEOMETRIC MEAN (ug/m^3)
75020 (Teachers College)	1971	8	0.0	0.0
	1972	41	0.6	0.1
	1973	28	3.0	0.1
	1974	48	0.9	0.1
	1975	40	0.6	0.1
	1976	18	0.6	0.2
	1977	--	--	--
	1978	6	1.1	1.0
	1979	12	1.7	0.5
75010 (OPP Station)	1979	45	0.6	0.0
	1980	40	0.6	0.1
	1981	5	0.2	0.1
	1982	44	0.8	0.1
	1983	54	0.4	0.1
	1984	23	0.3	0.1
	1985	40	3.5	1.0
	1986	33	5.1	0.8

-- Indicates missing or invalid data
Provincial Criterion: 100 ug/m^3(24 hr.)

TABLE 15

TOTAL LEVEL OF NITRATES IN SUSPENDED PARTICULATE IN THE NORTH BAY AREA FROM 1971 TO 1986

STATION	YEAR	NUMBER OF SAMPLES	MAXIMUM 24hr VALUE (ug/m^3)	GEOMETRIC MEAN (ug/m^3)
75020 (Teachers College)	1971	8	1.8	1.0
	1976	38	5.1	1.1
	1977	7	7.2	0.9
	1978	6	4.3	2.6
	1979	12	6.3	1.7
75010 (OPP Station)	1979	45	6.7	0.7
	1980	42	23.0	1.4
	1981	40	5.8	1.2
	1982	45	7.3	1.2
	1983	54	6.7	1.2
	1984	47	9.1	1.1
	1985	40	12.8	5.7
	1986	33	18.7	4.8

-- Indicates missing or invalid data
No Provincial Criterion

TABLE 16

TOTAL DUSTFALL LEVELS COLLECTED AT
TEACHERS COLLEGE, FIRST AVE./FRASER ST., STATION 75020, NORTH BAY
FROM 1972 TO 1979
(g/m^2/30 days)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1972	-	-	-	-	-	-	-	-	3.5	3.5	4.2	1.8	3.3
1973	1.4	1.8	4.9	9.5	5.3	12.6	7.4	4.9	7.4	2.5	2.5	-	5.5
1974	1.4	1.8	3.5	15.8	5.6	3.2	4.6	5.3	-	5.6	2.5	1.8	4.6
1975	2.8	1.4	-	5.6	4.9	6.7	6.0	4.2	2.5	3.9	3.9	-	4.2
1976	1.8	1.8	6.7	7.4	5.6	12.6	12.6	4.9	4.6	7.0	2.8	0.0	5.7
1977	7.0	-	-	5.1	-	9.1	6.6	3.8	3.9	-	1.6	-	4.4
1978	1.1	1.4	2.2	-	-	-	7.5	3.7	5.3	2.0	1.1	1.6	2.9
1979	1.3	1.4	1.5	4.5	8.1	Discontinued June, 1979							3.4

- Indicates missing or invalid data

Provincial Criterion: 7.0 g/m^2/30 days (30 day period)
4.5 g/m^2/30 days (1 year period)

Underlined data exceeds Provincial Criterion

TABLE 17

TOTAL DUSTFALL LEVELS COLLECTED AT OPP STATION, STATION 75010
NORTH BAY FROM 1979 to 1984
(g/m^2/30 days)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1979	-	-	-	-	-	-	0.9	1.7	2.6	1.6	0.9	1.3	1.5
1980	0.9	0.8	3.3	1.3	1.4	1.4	20.2	-	-	-	3.7	-	4.1
1981	-	-	5.7	2.1	2.7	6.9	3.0	0.2	0.6	-	2.2	0.3	2.6
1982	1.3	0.6	0.6	2.7	3.1	3.6	2.9	0.3	3.2	1.4	0.3	1.2	1.8
1983	1.2	1.4	1.8	1.1	2.2	4.3	1.5	1.4	-	3.2	1.6	1.5	1.9
1984	0.9	-	-	1.6									1.3

- Indicates missing or invalid data

Provincial Criterion: 7.0 g/m^2/30 days (30 day period)
4.5 g/m^2/30 days (1 year period)

Underlined data exceeds Provincial Criteria

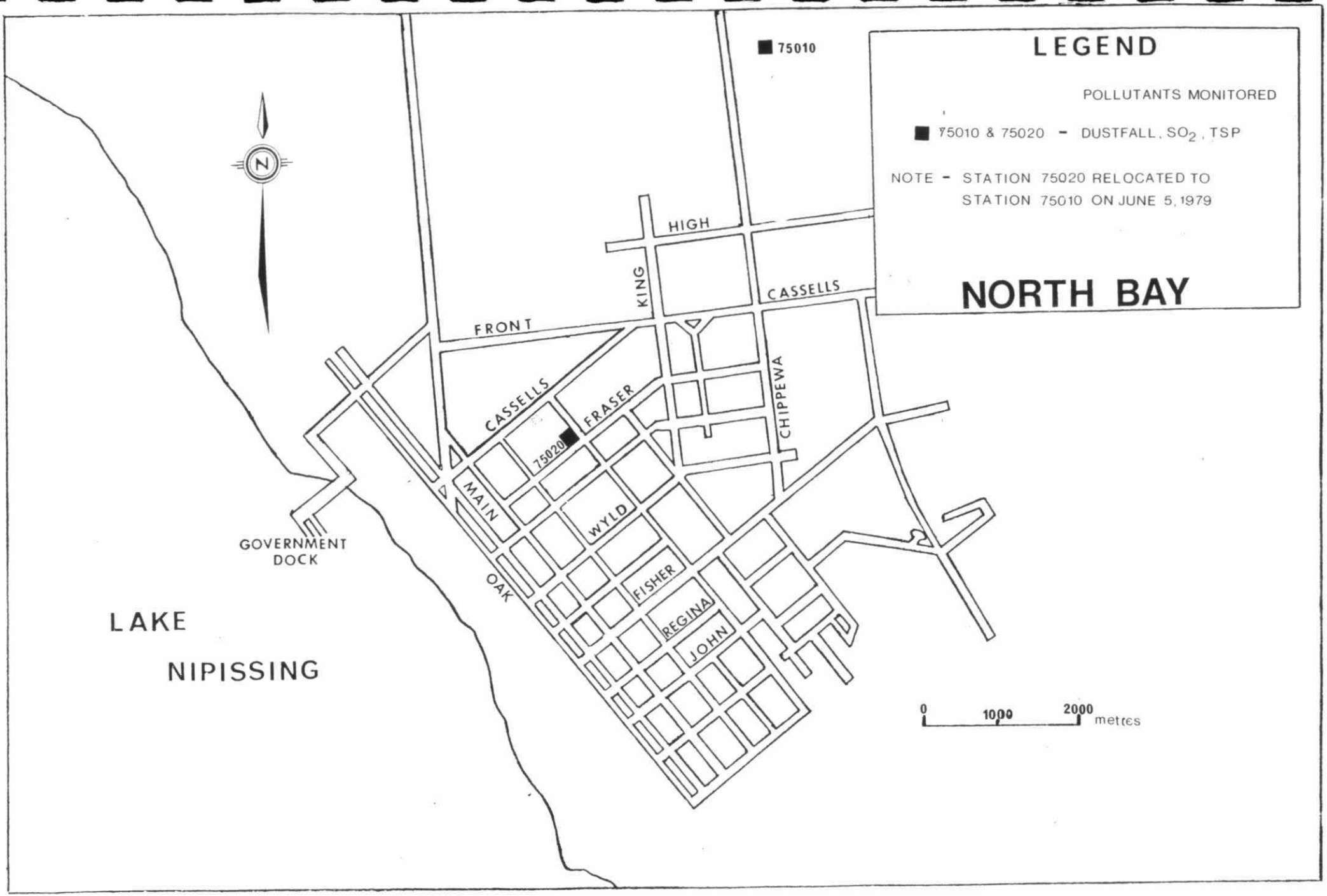

LEGEND
POLLUTANTS MONITORED
75010 & 75020 - DUSTFALL, SO_2, TSP
NOTE - STATION 75020 RELOCATED TO STATION 75010 ON JUNE 5, 1979
NORTH BAY
75010
75020
HIGH
KING
CASSELLS
FRONT
CASSELLS
FRASER
CHIPPEWA
MAIN
WYLD
OAK
FISHER
REGINA
JOHN
GOVERNMENT DOCK
LAKE NIPISSING
0
1000
2000
metres

Figure 1

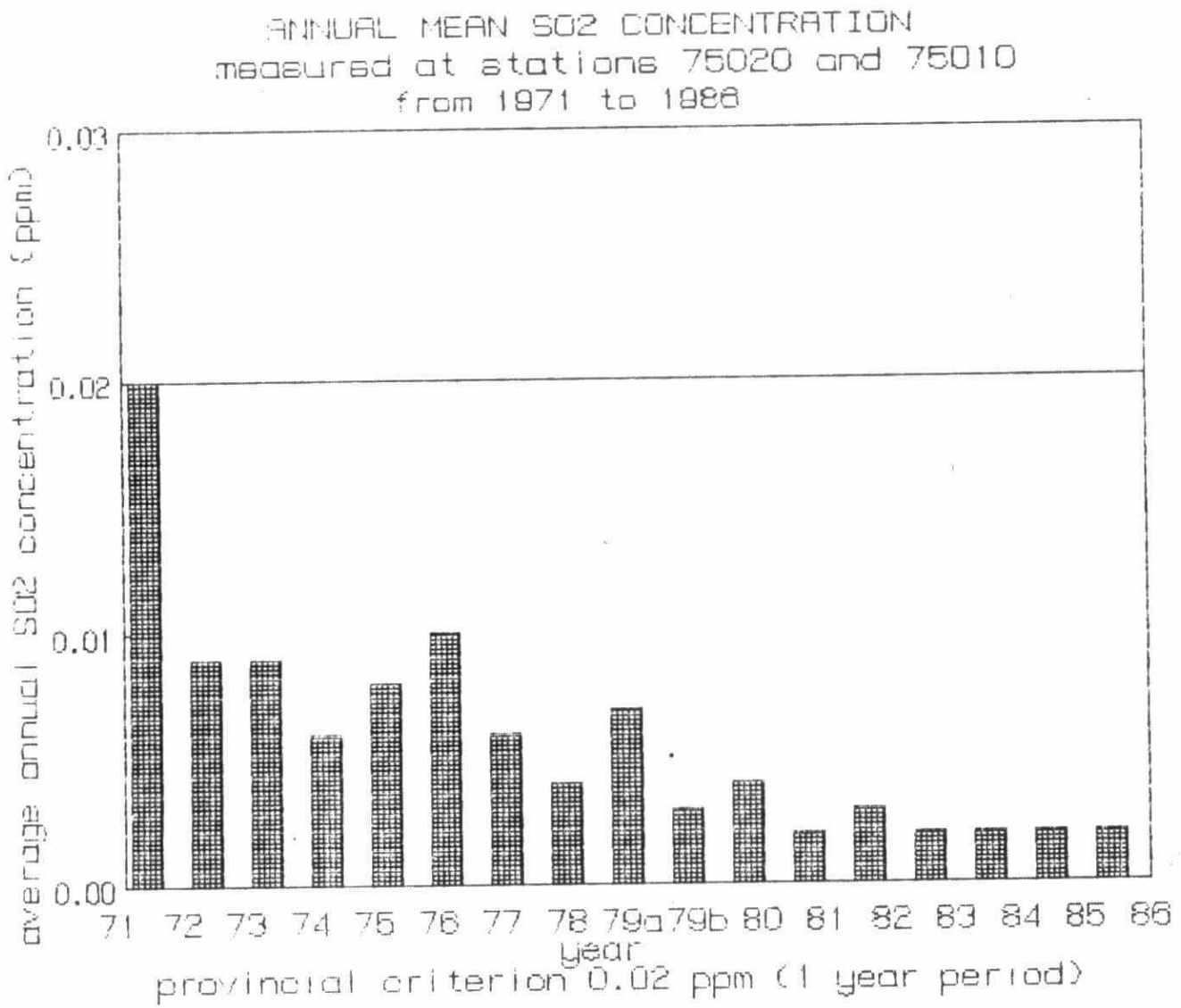

ANNUAL MEAN SO2 CONCENTRATION
measured at stations 75020 and 75010
from 1971 to 1986
average annual SO2 concentration (ppm)
0.03
0.02
0.01
0.00
71 72 73 74 75 76 77 78 79a 79b 80 81 82 83 84 85 86
year
provincial criterion 0.02 ppm (1 year period)

Figure 2

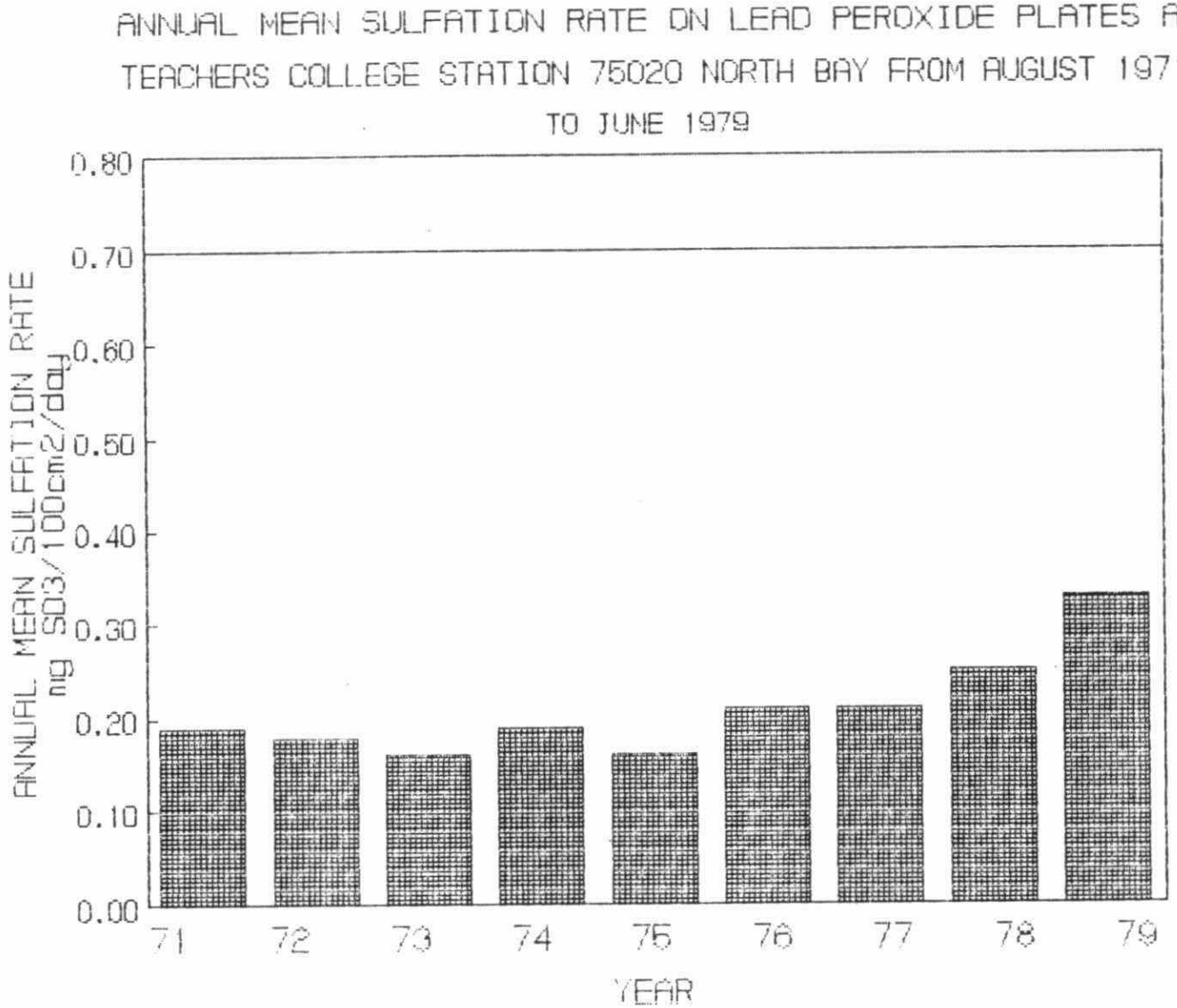

ANNUAL MEAN SULFATION RATE ON LEAD PEROXIDE PLATES AT
TEACHERS COLLEGE STATION 75020 NORTH BAY FROM AUGUST 1971
TO JUNE 1979
ANNUAL MEAN SULFATION RATE
mg SO3/100cm2/day
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
71
72
73
74
75
76
77
78
79
YEAR

Figure 3

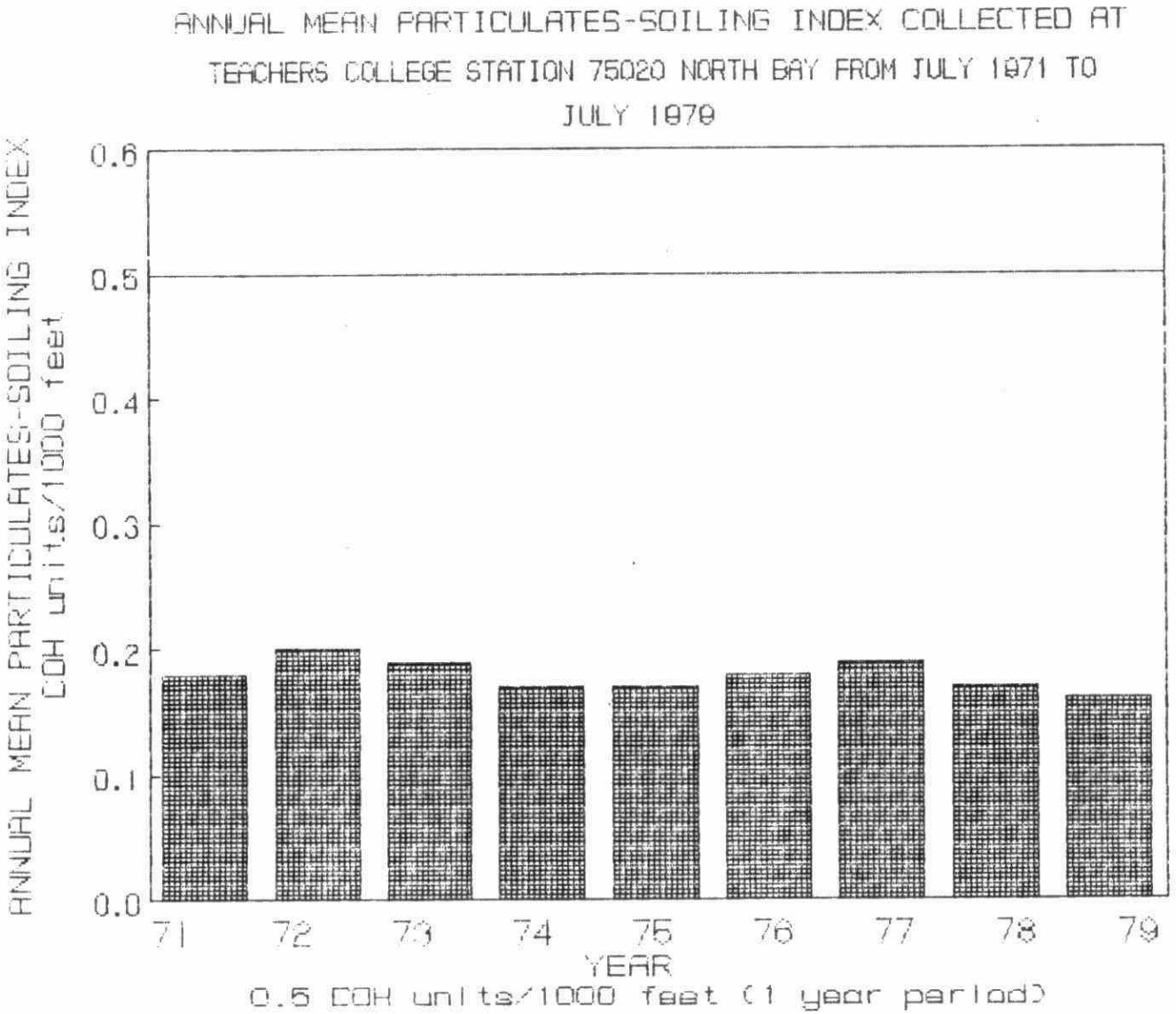

ANNUAL MEAN PARTICULATES-SOILING INDEX COLLECTED AT
TEACHERS COLLEGE STATION 75020 NORTH BAY FROM JULY 1971 TO
JULY 1979
ANNUAL MEAN PARTICULATES-SOILING INDEX
COH units/1000 feet
0.6
0.5
0.4
0.3
0.2
0.1
0.0
71
72
73
74
75
76
77
78
79
YEAR
0.5 COH units/1000 feet (1 year period)

Figure 4

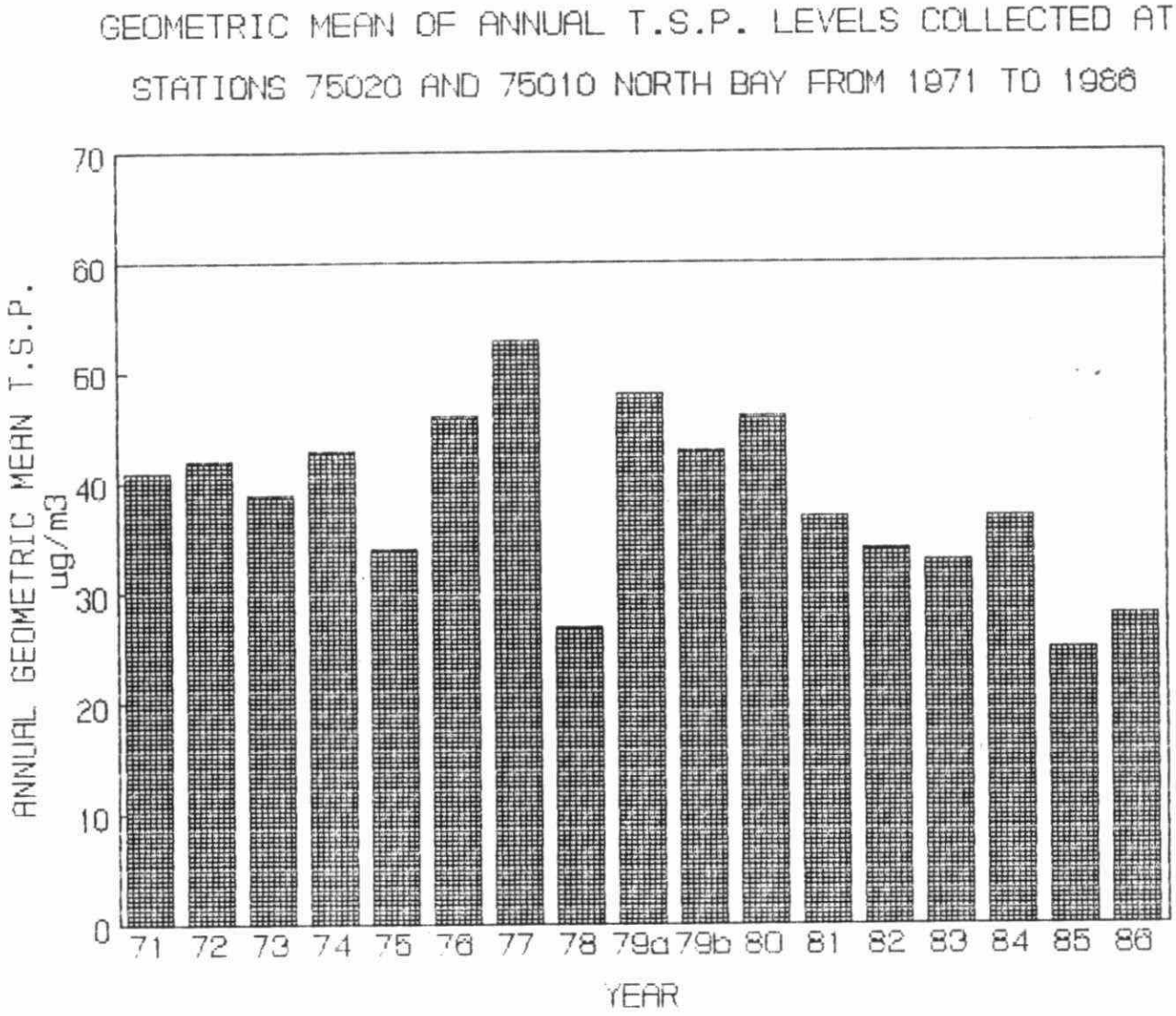

GEOMETRIC MEAN OF ANNUAL T.S.P. LEVELS COLLECTED AT
STATIONS 75020 AND 75010 NORTH BAY FROM 1971 TO 1986
ANNUAL GEOMETRIC MEAN T.S.P.
ug/m3
70
60
60
40
30
20
10
0
71 72 73 74 75 76 77 78 79a 79b 80 81 82 83 84 85 86
YEAR

Figure 5

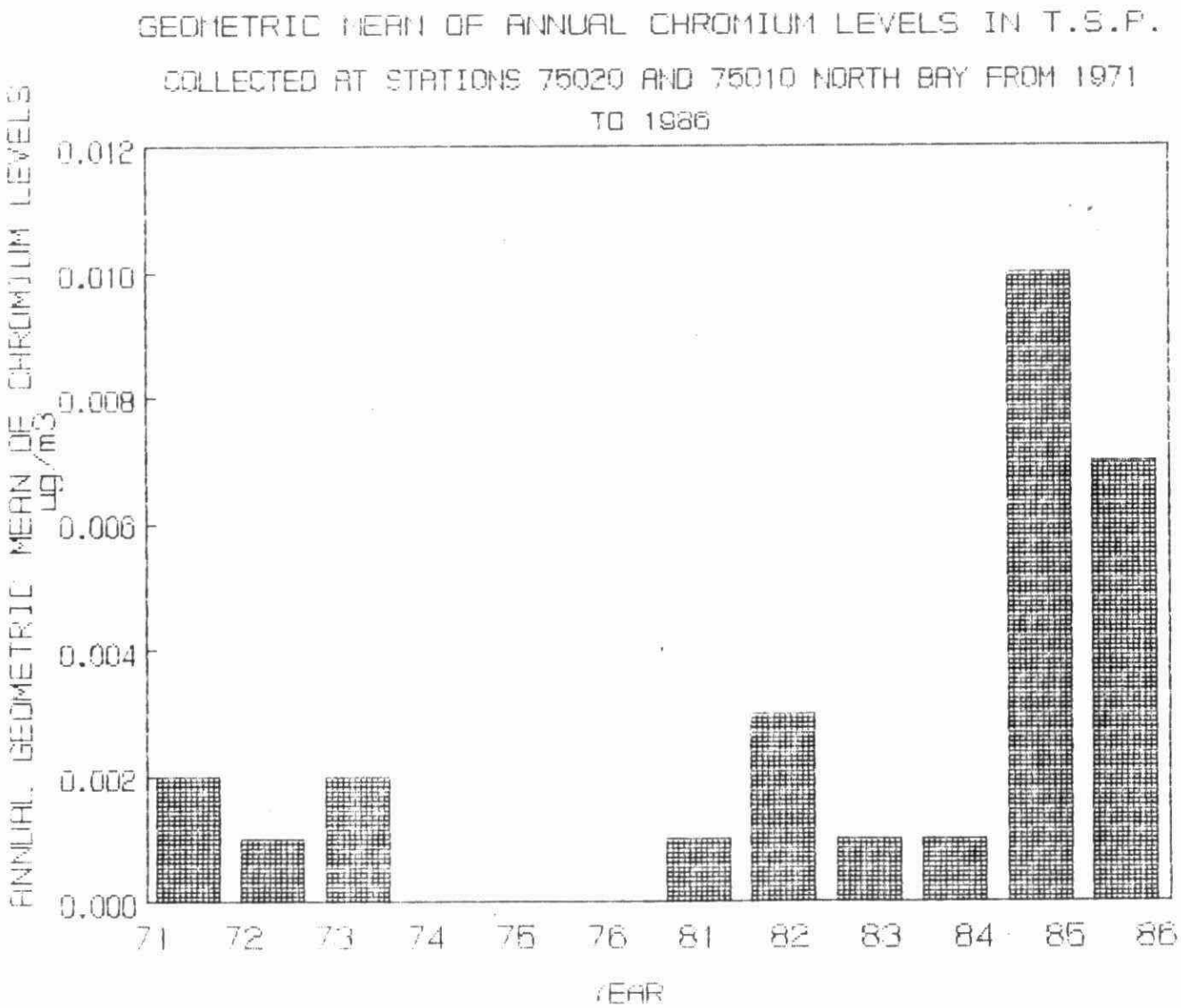

GEOMETRIC MEAN OF ANNUAL CHROMIUM LEVELS IN T.S.P.
COLLECTED AT STATIONS 75020 AND 75010 NORTH BAY FROM 1971 TO 1986
ANNUAL GEOMETRIC MEAN OF CHROMIUM LEVELS ug/m3
0.012
0.010
0.008
0.006
0.004
0.002
0.000
71
72
73
74
75
76
81
82
83
84
85
86
YEAR

Figure 6

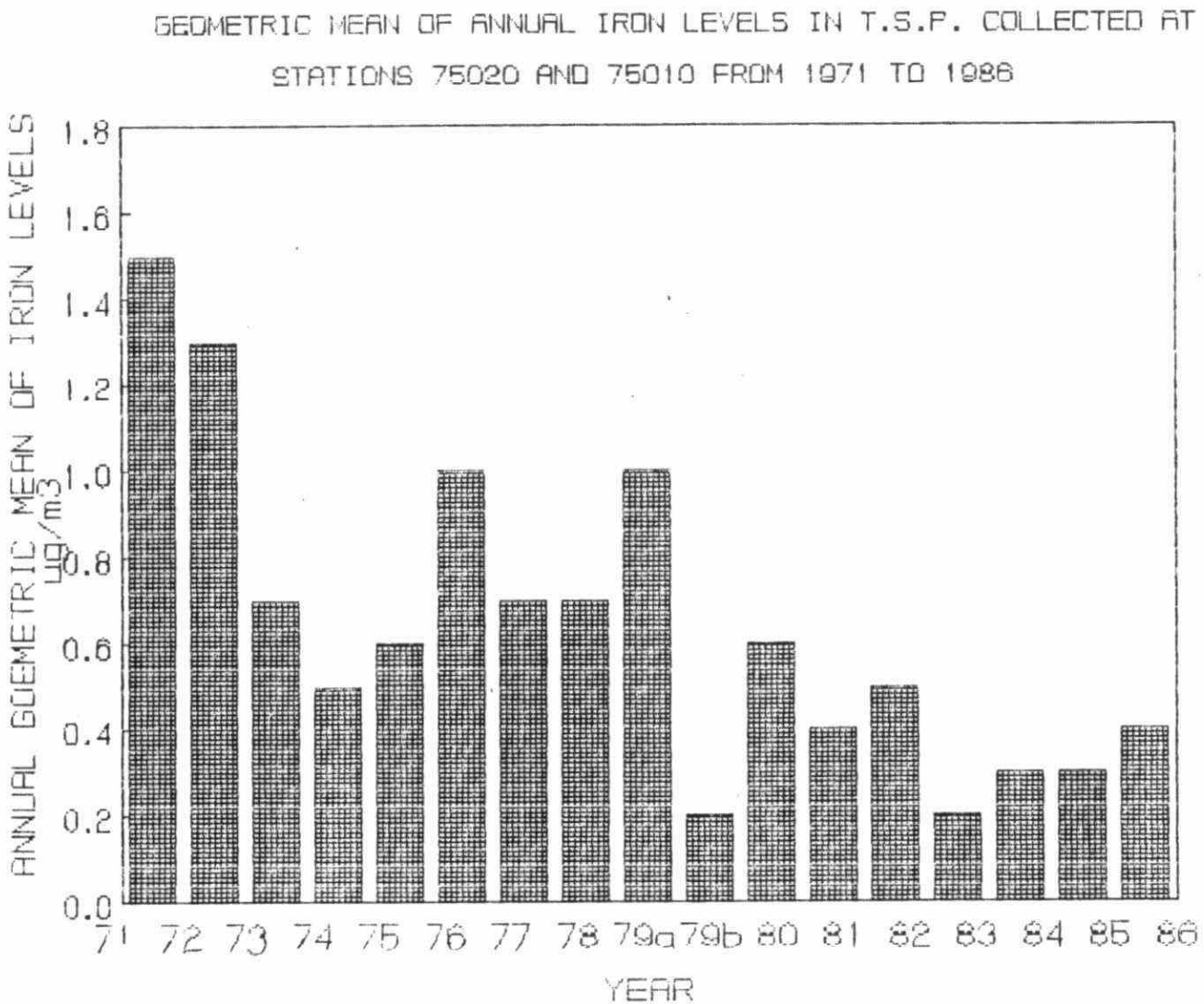

GEOMETRIC MEAN OF ANNUAL IRON LEVELS IN T.S.P. COLLECTED AT
STATIONS 75020 AND 75010 FROM 1971 TO 1986
ANNUAL GOEMETRIC MEAN OF IRON LEVELS
ug/m3
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
71 72 73 74 75 76 77 78 79a 79b 80 81 82 83 84 85 86
YEAR

Figure 7

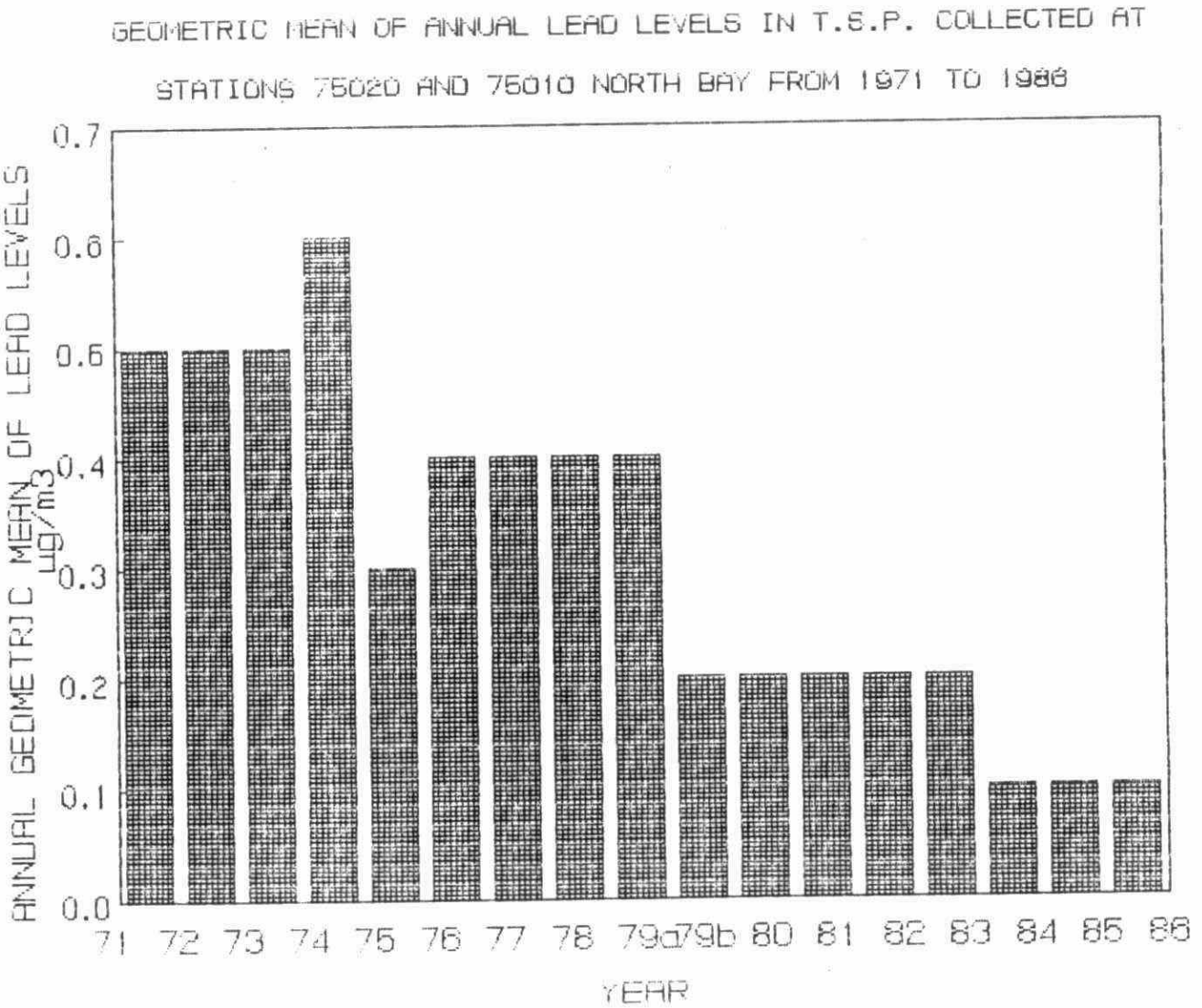

GEOMETRIC MEAN OF ANNUAL LEAD LEVELS IN T.S.P. COLLECTED AT
STATIONS 75020 AND 75010 NORTH BAY FROM 1971 TO 1986
ANNUAL GEOMETRIC MEAN OF LEAD LEVELS ug/m3
0.0
0.1
0.2
0.3
0.4
0.6
0.6
0.7
71 72 73 74 75 76 77 78 79a 79b 80 81 82 83 84 85 86
YEAR

Figure 8

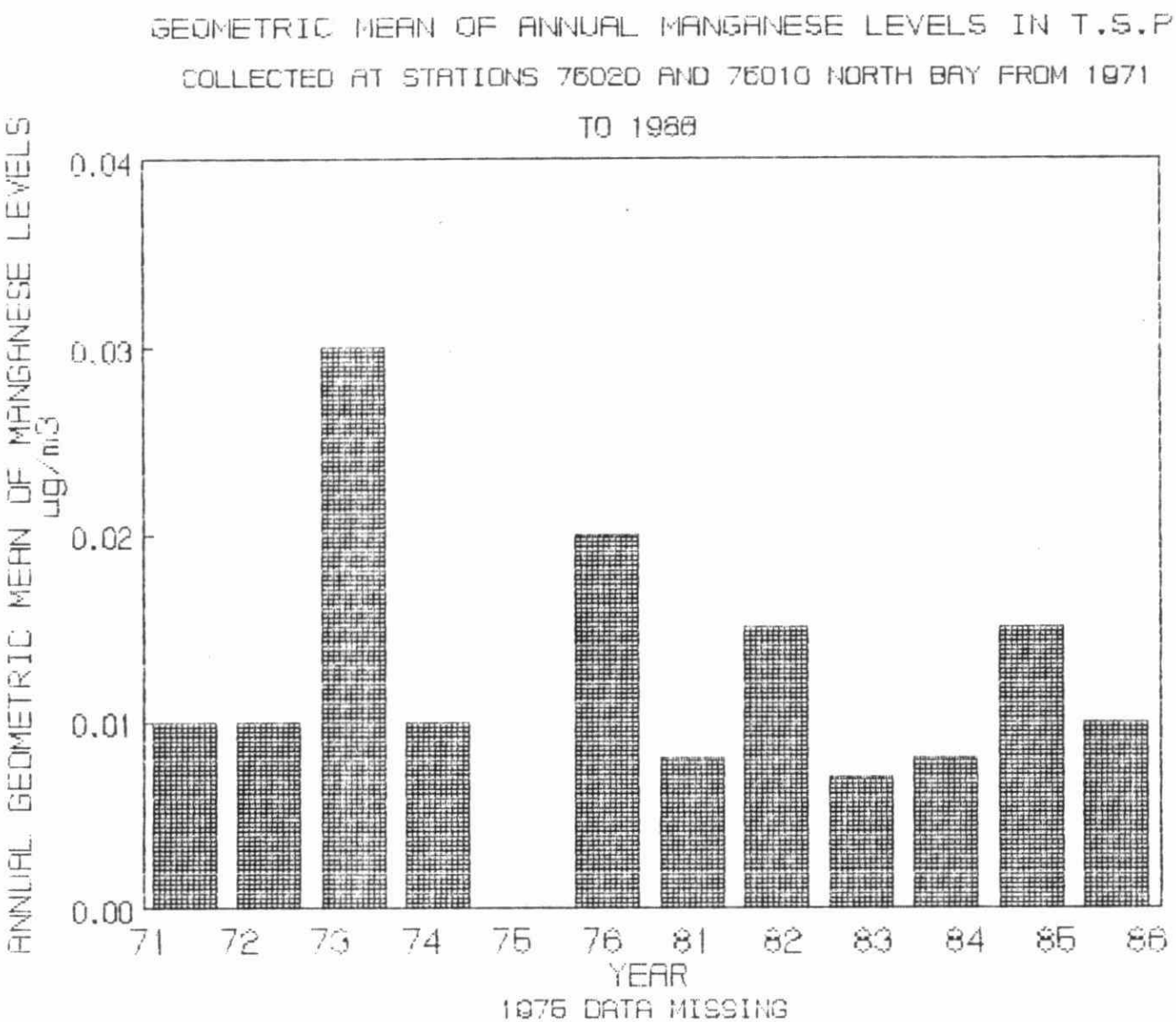

GEOMETRIC MEAN OF ANNUAL MANGANESE LEVELS IN T.S.P.
COLLECTED AT STATIONS 76020 AND 76010 NORTH BAY FROM 1971
TO 1988
ANNUAL GEOMETRIC MEAN OF MANGANESE LEWELS
ug/m3
0.04
0.03
0.02
0.01
0.00
71
72
73
74
75
76
81
82
83
84
85
86
YEAR
1975 DATA MISSING

Figure 9

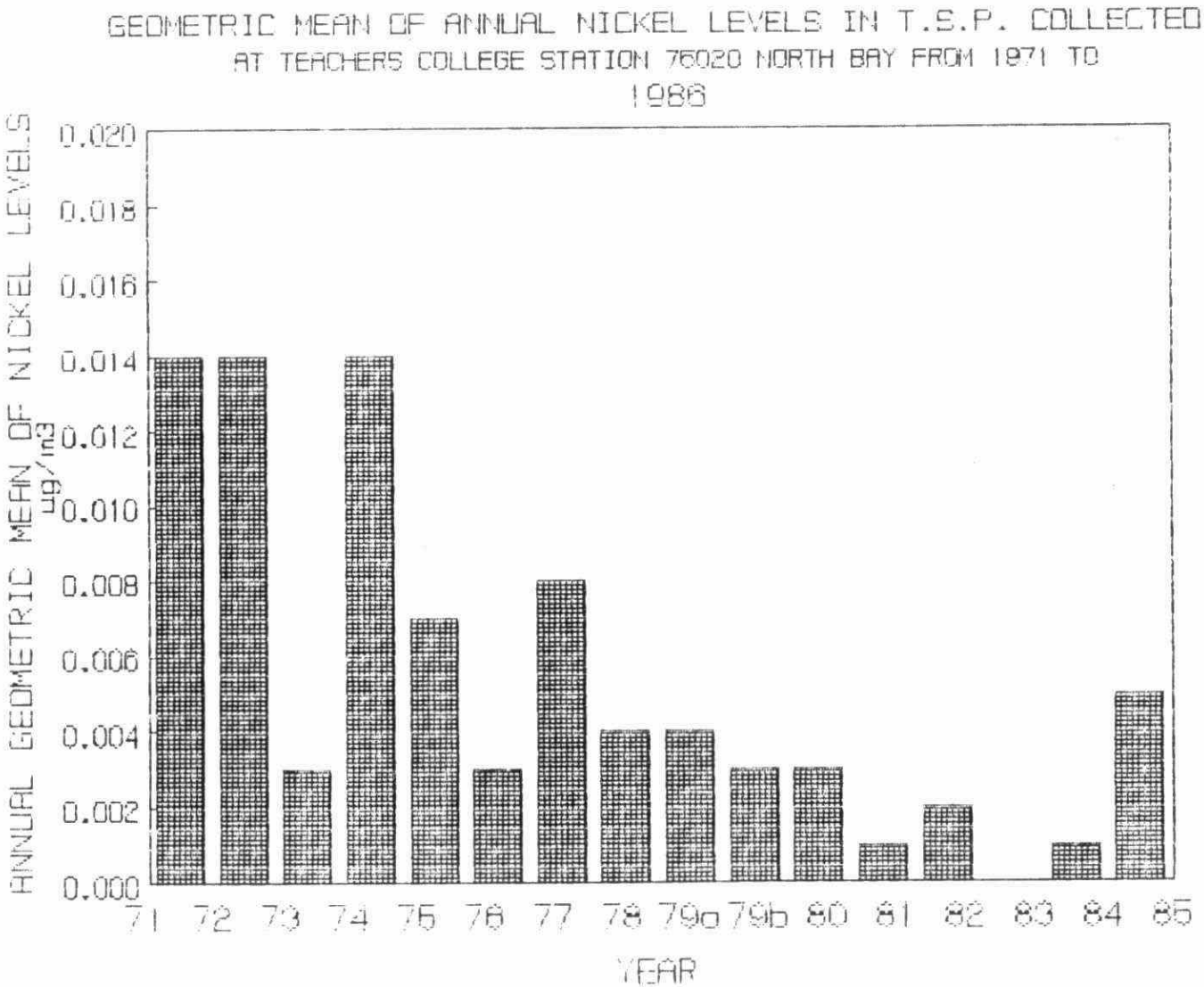

GEOMETRIC MEAN OF ANNUAL NICKEL LEVELS IN T.S.P. COLLECTED
AT TEACHERS COLLEGE STATION 76020 NORTH BAY FROM 1971 TO
1986
ANNUAL GEOMETRIC MEAN OF NICKEL LEVELS
ug/m3
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
71 72 73 74 75 76 77 78 79a 79b 80 81 82 83 84 85
YEAR

Figure 10

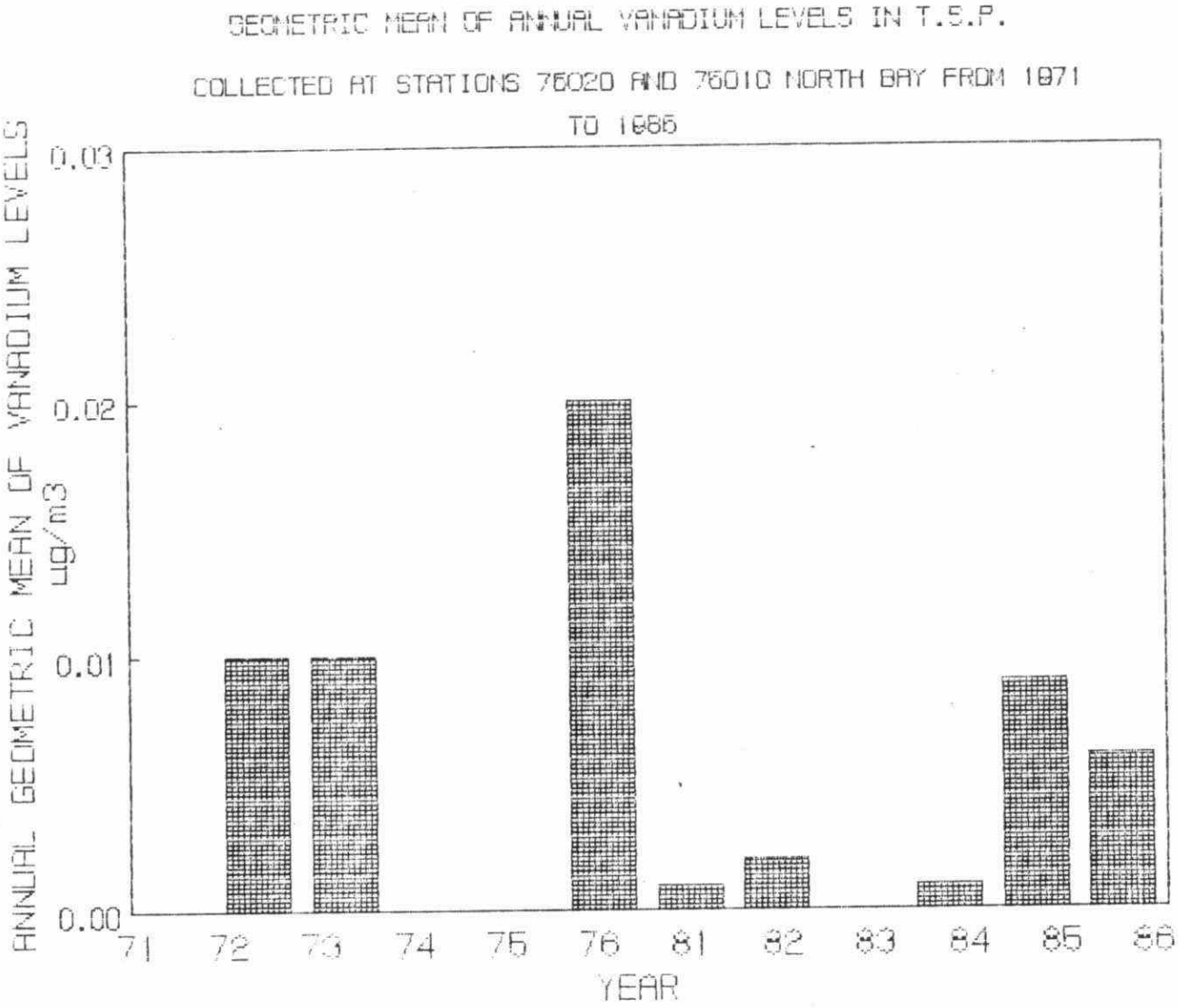
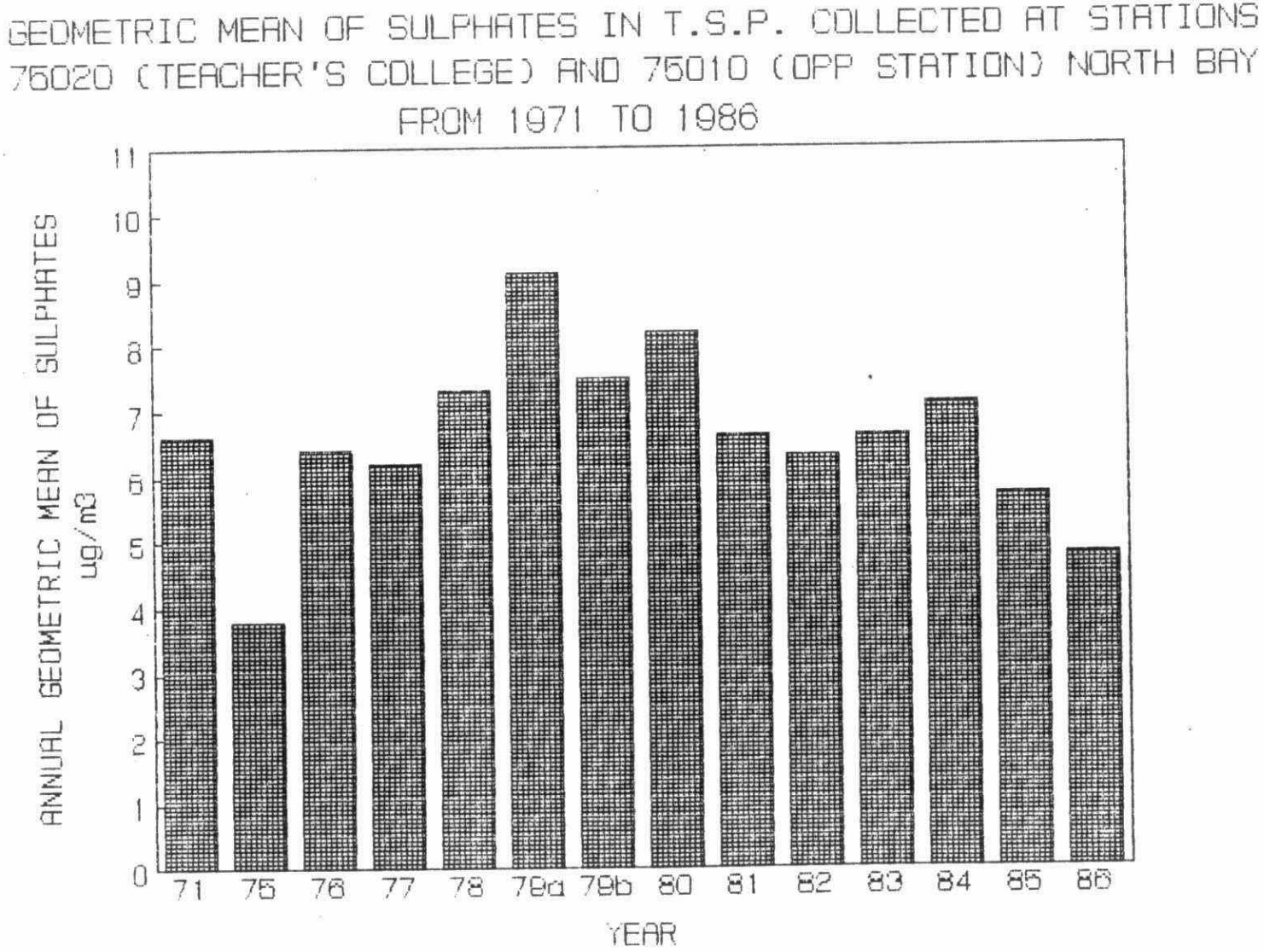

GEOMETRIC MEAN OF ANNUAL VANADIUM LEVELS IN T.S.P.
COLLECTED AT STATIONS 76020 AND 76010 NORTH BAY FROM 1971
TO 1986
ANNUAL GEOMETRIC MEAN OF VANADIUM LEVELS
ug/m3
0.03
0.02
0.01
0.00
71
72
73
74
75
76
81
82
83
84
85
86
YEAR

Figure 11


GEOMETRIC MEAN OF SULPHATES IN T.S.P. COLLECTED AT STATIONS
76020 (TEACHER'S COLLEGE) AND 75010 (OPP STATION) NORTH BAY
FROM 1971 TO 1986
ANNUAL GEOMETRIC MEAN OF SULPHATES
ug/m3
0
1
2
3
4
5
6
7
8
9
10
11
71
75
76
77
78
79a
79b
80
81
82
83
84
85
86
YEAR

Figune 12

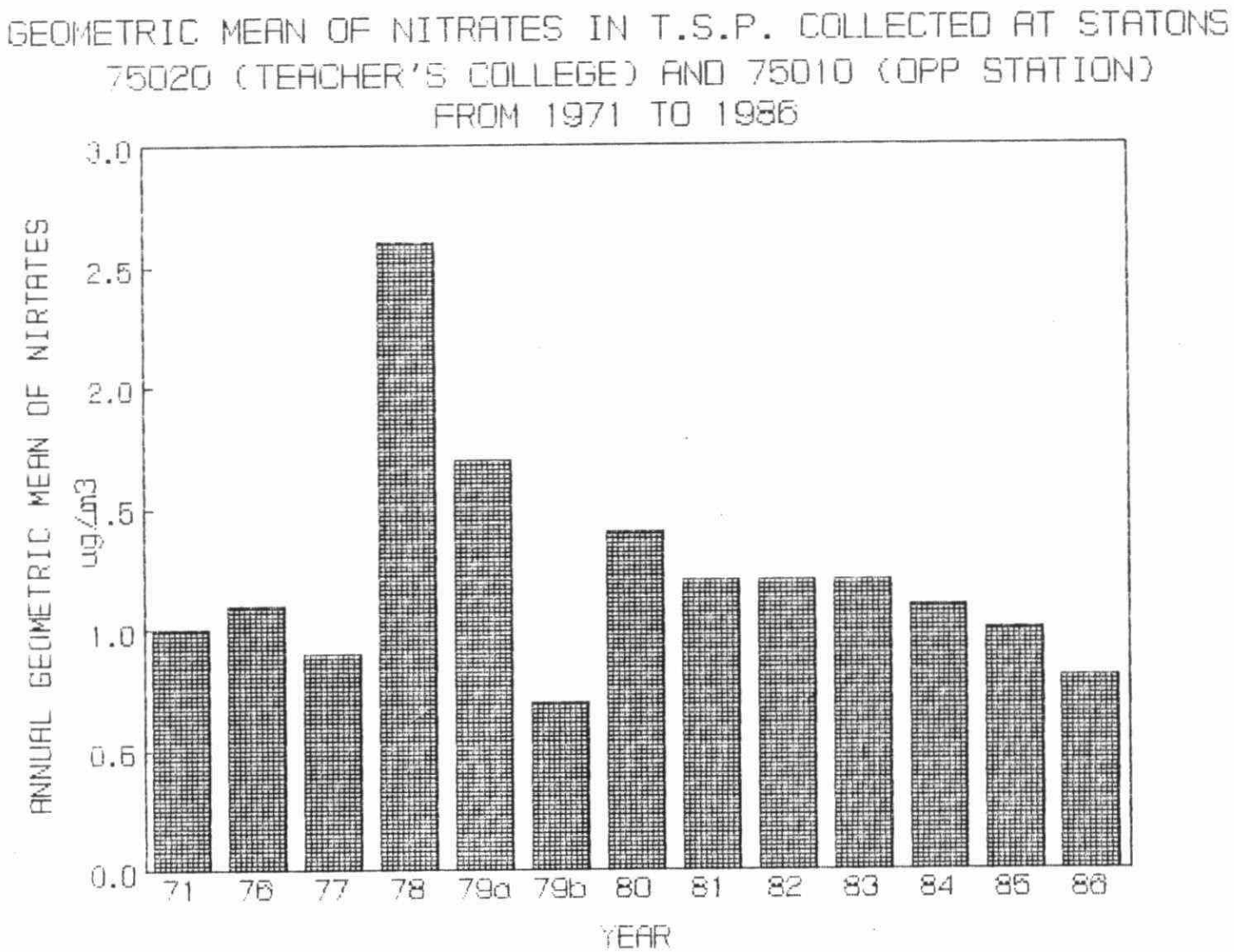

GEOMETRIC MEAN OF NITRATES IN T.S.P. COLLECTED AT STATONS
75020 (TEACHER'S COLLEGE) AND 75010 (OPP STATION)
FROM 1971 TO 1986
ANNUAL GEOMETRIC MEAN OF NIRTATES
ug/m3
3.0
2.5
2.0
1.5
1.0
0.5
0.0
71
76
77
78
79a
79b
80
81
82
83
84
85
86
YEAR

Figure 13

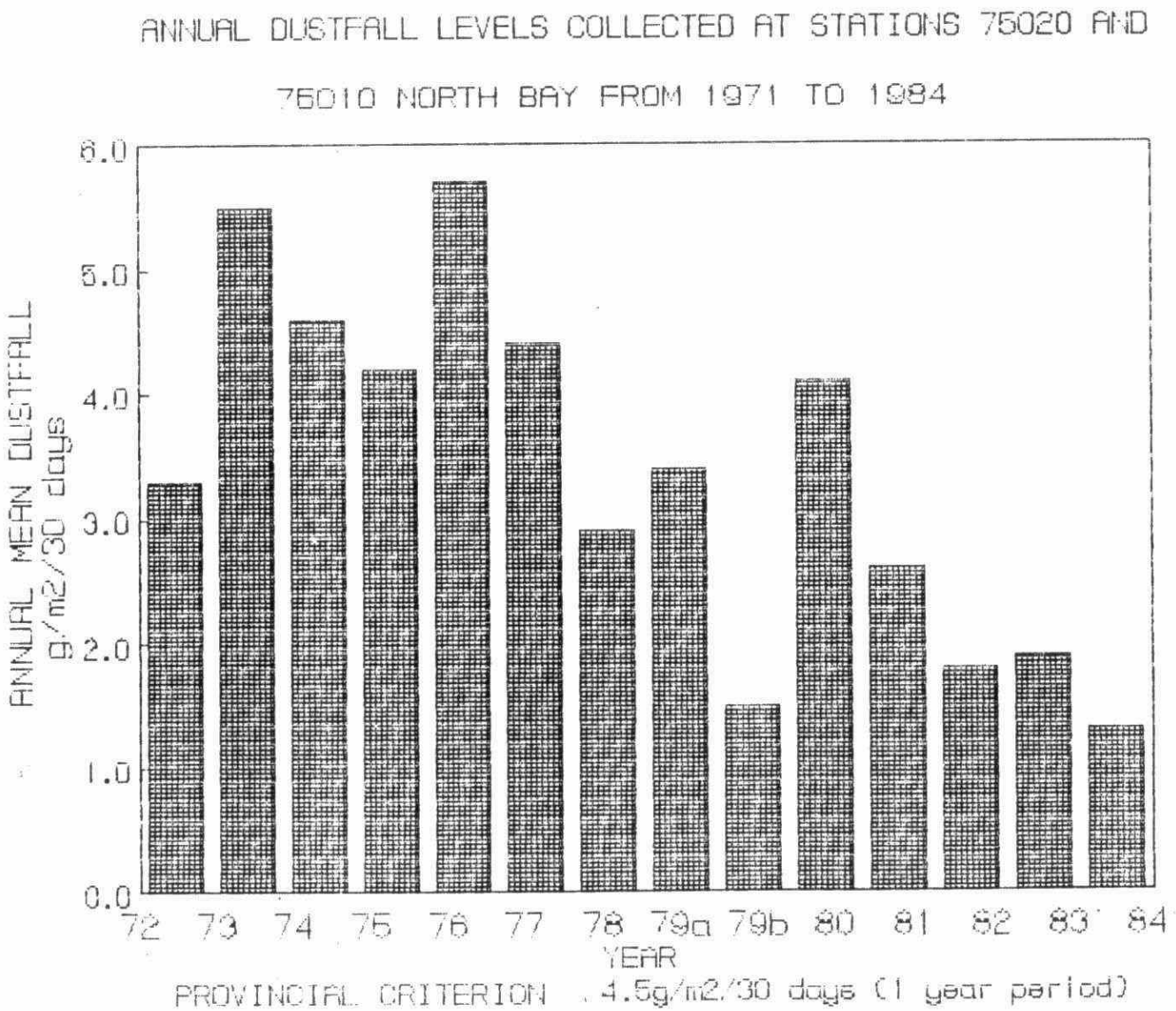

ANNUAL DUSTFALL LEVELS COLLECTED AT STATIONS 75020 AND
76010 NORTH BAY FROM 1971 TO 1984
ANNUAL MEAN DUSTFALL
g/m2/30 days
6.0
5.0
4.0
3.0
2.0
1.0
0.0
72 73 74 75 76 77 78 79a 79b 80 81 82 83 84
YEAR
PROVINCIAL CRITERION 4.5g/m2/30 days (1 year period)

Figure 14

APPENDIX

Method for Measuring Sulphur Dioxide (SO_2) Using the Conductimetric Method

Highly purified (distilled) water is considered a poor conductor of electricity. However, it becomes a very good conductor when certain substances are dissolved in it. These substances include acids, salts, bases and certain so-called acid forming gases such as hydrogen chloride, sulphur trioxide and sulphur dioxide. The increase in conductivity of water is proportional to the amount of dissolved material.

The dissolved gas breaks into individually charged atoms or groups of atoms called ions, or becomes ionized. These ions are able to carry electrical charges or current between two electrodes placed in the solution, providing the electrodes are at different potentials. The current through the solution is proportional to the voltage between the electrodes. If the potential applied to the electrodes is direct current, eventually a thin film of gas will form on them causing them to become "polarized", which in turn gradually increases the electrode resistance.

It is possible to measure changes in this "electro conductivity". Measurements are based on changes in conductivity of the water through which air is constantly passed.

The detector or "cell" consists of a gas scrubbing column, a liquid/gas separator and two sets of electrodes (water check and measurement). De-ionized water and sample gas are fed to the cell through two separate ports and are mixed in the scrubbing column. Any sulphur dioxide or soluble gas present dissolves in water. The solution is separated from the main body of sample gas and is passed over the measurement electrodes.

If sulphur dioxide or a similar gas is present in the sample stream, the conductivity of the solution between the electrodes is increased, causing a net decrease in the cell resistance.

A potential is applied across the the electrodes through a rectifying bridge circuit. A decrease in cell resistance causes an increase in current through the rectifier and a corresponding increase in the output voltage. This voltage is applied to either an indicating meter or a potentiometric recorder to obtain a visual indication of the amount of SO_2 present in air expressed as parts per million on an air volume basis.

Method for Measuring Sulphur Dioxide (SO_2) Using the Coulometric Titration Method

This type of sulphur dioxide analyzer continuously measures and indicates the concentration of sulphur dioxide in the atmosphere. The instrument incorporates principles of secondary coulometry and dynamic iodimetric titration to achieve measurements.

The detector cell contains an anode, a cathode and a reference electrode. These three electrodes are immersed in a buffered electrolyte, which is continuously cycled within the detector. A constant-current source continuously generates iodine at the anode by anodic oxidation of the iodide ion and reduces the iodine formed to iodide ion by cathodic reduction at the cathode. During operation of the cell, an equilibrium concentration of iodine provides reaction capability for SO_2 detection.

When an atmospheric sample is introduced, the sulphur dioxide component undergoes hydrolysis in the electrolyte. The hydrolysis product acts as a chemical reductant to the steady-state concentration of iodine existing in the cell, and a decrease in the steady-state iodine concentration ensues. This effect causes an electrochemical imbalance in the cell, as there is not sufficient iodine present to carry the charge being supplied to the cell by the constant-current source. A fraction of the applied current, related to the electrochemical unbalance, is forced to flow through the reference electrode as an alternate current path. This current is quantitatively related to the sulphur dioxide concentration and is equivalent to the differential between the anodic and cathodic currents.

Method for Measuring Sulphation Rate Using the Lead Peroxide (PbO_2) Plates

Sulphation rate is measured by exposing small plastic plates coated with lead peroxide (PbO_2) to the atmosphere for 30-day periods. The PbO_2 reacts with gaseous sulphur dioxide to form lead sulphate. The quantity of sulphate formed is analytically determined and reported as milligrams of sulphur trioxide (SO_3) per hundred square centimetres of exposed PbO_2 impregnated material per day (mg SO_3/100 cm^2/day). The method is normally used to detect the presence of sulphur dioxide, but other reactive sulphur compounds, such as H_2S may also be converted to the sulphate form.

The Provincial criterion for sulphation, outlined in Ontario Regulation 296, is 0.7 mg SO_3/100 cm^2/day for a 30-day exposure.

Method for Measuring Sulphur Dioxide (SO_2) Using the Pulsed Fluorescent Monitor

The pulsed fluorescent sulphur dioxide (SO_2) monitor operates on the principle that SO_2 molecules excited by ultraviolet light give off radiation.

Pulsating ultraviolet light is focused through a narrow filter into the fluorescent chamber. Here it excites SO_2 molecules which give off their characteristic decay radiation. A second filter allows only this radiation to fall on a photomultiplier tube. Electronic signal processing transfers the light energy impinging on the photomultiplier into a voltage which is in direct proportion to the concentration of SO_2 in the sample stream being analyzed.

More specifically, light in the 230 nm-190 nm region is used because it exhibits minimal interference by air and most other molecules that are found in ambient air. The pulsed light source emits ultraviolet radiation which acts on the SO_2 in the sample gas producing electronically excited SO_2. The electronically excited SO_2 can then decay back to the ground state by fluorescence. The following equation outlines the overall reaction where SO_2 is excited SO_2^*, k_f is a rate constant and hv refers to the energy released by the reaction.

$$SO_2^* \xrightarrow{k_f} SO_2 + hv_2$$

The fluorescent radiation impinging upon a detector is directly proportional to the concentration of SO_2, thus forming the basis for this measurement technique.

Method for Measuring Particulate Matter Using the Dustfall Monitoring Technique

Dustfall (total) comprises the larger, more visible, particulate matter which settles out from the atmosphere by gravity. It is measured by exposing an open top plastic jar for approximately 30 days.

The total amount of dustfall is determined by weighing the contents of the jar and expressing the results in $g/m^2/30$ days.

The settleable particulate collected in the dustfall jar can be separated into a soluble and an insoluble fraction for further analysis. The insoluble portion can be examined by optical microscopy to determine the composition of the particulate.

Although this method of sampling can be variable and is dependent on external factors such as wind and the amount of rain and/or snowfall during the sampling period, it is very useful in determining the amount of settleable particulate in the atmosphere.

Provincial Criteria for total dustfall are 7.0 $g/m^2/30$ days (grams per square meter per 30 days) and 4.5 $g/m^2/30$ days averaged over a 12 month period.

Method for Measuring Particulate Matter Using the High Volume Sampling Technique

The high volume (hi-vol) sampling technique determines the mass concentration of suspended airborne particulate ($\leq$100 microns) by drawing a known volume of air through a pre-weighed filter medium. Standard operation of the sampler involves air flow rates from 0.9 to 1.4 m^3/minute and the use of a Gelman AE glass fibre filter. The sample is collected over a 24-hour period, midnight to midnight, every one, three or six days. The six-day operating schedule is pre-determined and is consistent throughout Canada and the United States. This six-day sampling is considered to be representative of the air quality over a year.

Two criteria for desirable air quality exist for total suspended particulate matter. One is 120 ug of suspended particulate per cubic metre of air averaged over a 24-hour period. The other is an annual geometric mean of 60 ug/m^3. The 24-hour criterion is based on impaired visibility and adverse health effects (in combination with sulphur dioxide), while the annual criterion is based on public awareness of suspended particulate and subsequent aesthetic effects.

High-volume samples may also be analysed for trace metals and compounds.

Method For the Measurement of Soiling Index Due to Particulate Matter

Ambient air is drawn through a circular area of filter paper at a known sampling rate for a one hour sampling period. This operation is repeated automatically on fresh areas of paper at equal time periods. The absorbance of the circular spots or stains is measured in comparison with that of the clean paper with a photometer using white light of wavelength from 500-800 nm. For comparison purposes, the absorbance readings are reported in coefficient of haze (COH) units per 1000 linear feet of air sampled.

The soiling index, in terms of coefficient of haze (COH) units, is related to the effect of the sampled atmosphere when it is drawn through a clean white filter paper. One COH unit is defined as that quantity of light scattering by particulate matter which produces an absorbance equivalent of 0.01:

Absorbance = $\log_{10} I_o/I$

I_o = intensity of light passing through the clean filter paper

I = intensity of light passing through the soiled paper

For comparison purposes with similar samples in other areas, COH units are normalized by dividing the absorbance by the volume of sample air expressed in multiples of 1000 linear feet.

Ambient air quality criteria for coefficient of haze outlined in Ontario Regulation 296 are 1.0 COH units per 1000 feet for a 24-hour period and 0.5 COH unit per 1000 feet of air for one year.